STATUS REPORT
ON
ANCHOR ROD CORROSION

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U. S. DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION
TECHNICAL STANDARDS DIVISION

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A. INTRODUCTION

Reports of premature weakening and failure of anchor rods due to corrosion have been received from scattered areas in several parts of the United States. The problem is under investigation, and the information now on hand regarding it is summarized in this report for use by those who are concerned with underground corrosion.

Corrosion of anchor rods has usually been the most rapid on deeply buried parts of the rods and consequently may not be noticed until failures occur or anchor rods are removed during reconversion work.

B. CAUSES OF CORROSION

Excessive corrosion is attributed to one or more of several causes, which may be described as follows:

1. Galvanic Corrosion: Galvanic action due to differences in potential between unlike metals surfaces in contact with the soil can cause rapid corrosion under certain soil conditions favorable to such action. A steel anchor rod and copper ground rod buried in soil that acts as a suitable electrolyte will behave like a battery with steel and copper electrodes. The voltage measured above ground between these electrodes might show that the copper is 0.3 to 0.5 volts positive with respect to the steel, and connecting the electrodes together through the system neutral under such conditions will result in a flow of direct current in the neutral from copper ground rods to the steel anchor rods. As the current leaves the steel anchor rods in the earth, the chemical reaction causing current flow removes material from the steel rod just as the negative plate of a battery loses material while the battery discharges.

   The galvanic current is limited by the resistance of the earth and is further reduced by chemical reactions that tend to polarize the electrodes. These factors prevent serious trouble from developing under most conditions.

Galvanic action also can take place between different parts of an anchor rod not connected to the system neutral. The oxides forming on metal at the surface of the earth tend to make current flow from deeply buried parts of the rod through the soil to the oxidized parts of the rod. This action is likely to be much slower than that resulting between copper and steel electrodes under similar soil conditions.

2. Corrosion by Soils: Corrosive soil elements or soil micro-organisms may cause excessive corrosion in some cases, particularly where anchors are installed in made soil containing ashes or cinders or in soils with a high sulfur content. This type of corrosion is likely to be accompanied by galvanic corrosion such as has been described.
3. Electrolysis: Electrolysis due to direct currents from an external source may be important, particularly in areas near underground pipe lines. The cathodic protection systems using rectifiers and buried anodes cause direct currents to flow in the earth from the buried anodes toward the pipe line, for the purpose of protecting the pipe line against corrosion. Where multigrounded distribution lines are located nearby, the currents will flow along the neutral conductor, also. Wherever the currents leave the neutral, in areas nearest the pipe line, metal will be removed from all underground electrodes including anchor rods and ground rods at a rate proportional to the amount of current flowing.
   This type of action is likely to involve larger currents and more rapid destruction of electrodes than will occur for the galvanic action first described.

C. REDUCING CORROSION DAMAGE

The most effective measures for reducing damage will differ with circumstances. It is important to recognize that electrolytic corrosion caused by external dc sources will not be relieved by some of the measures that are most effective for preventing underground corrosion due to other causes.

1. Galvanic Corrosion: Where electrolysis is not a factor, excessive corrosion of anchor rods can usually be relieved either by installing strain insulators in guys to break the galvanic circuit or by using metals of similar potentials for ground rods, anchor rods, and anchors. Unfortunately, neither of these remedies is easily applied to an existing distribution line.

   Installation of strain insulators in guys offers the quickest remedy for galvanic corrosion of steel anchor rods due to the higher potential of copper

ground electrodes. However, a question arises as to whether the National Electrical Safety Code permits use of strain insulators in some guys when they are not used in all guys throughout the system. A clarification of Rule 283 in regard to such a practice has been requested. For the present, it seems reasonable to consider installing strain insulators where serious corrosion to anchor rods will result without them.

Copperweld, bronze, or stainless steel anchor rods used with concrete or creosoted log anchors offer the most effective remedy where severely corrosive conditions exist. These metals have substantially the same galvanic potential as the copper ground electrodes so that destructive currents should not result where they are used. Also, they are resistant to other corrosive conditions that may prevent a galvanized steel rod from giving satisfactory service even when it is isolated from the system neutral.

Steel anchors used with the corrosion resistant rods referred to above are likely to corrode where the rods are attached. For that reason they should not be so used, since it is assumed that the corrosion resistant rods are used only where conditions favor underground corrosion.

It should be recognized that a copperweld rod that is damaged so that the steel core is exposed at any point underground, or one that has pin holes in the copper with the same results, will be subjected to rapid corrosive action. The copper covering has the effect of accelerating corrosion of the steel core.

2. Soil Corrosion: Conditions favoring corrosion by elements in the soil or by soil micro-organisms are also likely to favor galvanic corrosion. As a result, the more rapid galvanic action may prevent the soil corrosion effects from being noticed until measures have been taken to prevent the galvanic action. The possibility of this soil corrosion or of galvanic action between deeply buried parts of a steel rod and other parts near the surface should be considered where rapid corrosion is apparently caused by galvanic action between steel anchor rods and copper ground rods. It is wise to use corrosion resistant anchor rods and anchors at any location where rapid corrosion has caused anchor rod failure within a few years or less instead of depending on strain insulators alone to protect galvanized steel rods.

3. Electrolysis: When a direct current flows in the system neutral because of an external voltage source, such as a cathodic protection system for a pipe line or a dc street railway system, the damage results

where current flows from the neutral into the earth. Under such conditions little or nothing will be gained by using corrosion-resistant metals. Anchor rods can be protected by installing guy strain insulators as discussed in connection with galvanic corrosion; however, this will have the effect of concentrating additional damage on ground rods and pole butt grounds. For replacing ground rods near a pipe line, 3/4 inch or 1 inch steel rods may be most economical, as the life of the rods will be proportional to the amount of metal used.

To minimize the damage due to electrolysis, cooperation should be requested from the agency that owns the pipe line. Much may be gained by considering this factor when power distribution lines are built or cathodic protection systems are installed and some helpful changes may be practicable where they are already installed.

The following are suggested as methods for reducing damage:

a) Keep as much separation as possible between buried anodes of the protection system and all ground rods or anchor rods connected to the system neutral.

b) At points near the pipe line, check regularly for corrosion damage and use grounding electrodes that can be replaced at minimum cost. Keep ground rods away from the pipe line as far as possible. If corrosion destroys the down leads or the connection to ground electrodes before the electrodes themselves have been destroyed, use insulated (waterproof) down leads and cover the connection with waterproof tape, tar, or similar insulating material.

c) The most complete protection will result from applying the same negative dc voltage to the system neutral conductor as to the pipe line. This will cause current to flow <u>into</u> the ground electrodes from the earth, protecting them from corrosion in the same manner as the pipeline is protected. However, this may throw a large additional burden on the pipe line protection system.

D. CHECKING FOR CORROSION DAMAGE

The most reliable means of checking for excessive underground corrosion is by exam-

ination of anchor rods that are removed from service for any reason. The rods are likely to be weakened most near the point of attachment to the anchor.

Galvanic action between ground rods and anchor rods or electrolytic action due to external dc sources can be detected by measuring the direct current flowing to the anchor. However, the alternating current flowing to ground from the neutral of an energized line is usually much greater than the direct current, and would probably damage a meter sensitive enough to measure the small direct current.

The following suggestions for measurement of current are tentative, but are included as a method of electrical detection that is believed to be workable under the conditions likely to be encountered. Additional field experience in detection of corrosion is needed. To make the best possible information available at an early date, results of tests and any suggestions for improved methods should be forwarded to REA.

The instrument suggested for electrical measurements is a multiple scale dc milliammeter, such as is often used in radio repairing and should be obtainable from most electrical suppliers. Most volt-ohm-milliammeters for radio repairing or miscellaneous testing will include milliampere scales of the proper range, and should be available for $40 or less. The meter used should have one range of approximately 0 to 100 milliamperes (0 to 0.1 ampere) dc, and preferably one higher and one lower dc range also. A light weight two conductor test lead with color coded wires, approximately 30 feet long, may be helpful in making measurements.

Measurements may be made as follows:

1. At a guyed pole that is grounded, disconnect the ground wire and the guy from the neutral, then measure the current between the ground electrode and the guy with the milliammeter.
2. When a section of line is de-energized for some reason, disconnect the guy or ground wire from the neutral and measure direct current by connecting the milliammeter to the guy or ground wire and to the neutral conductor.

To avoid damaging the meter in case a fairly large direct current is flowing, use a higher range such as 0 to 1 ampere dc before a more sensitive range is used. If a negative reading is obtained, reverse the connections to the meter. It should be noted that the current flows from the neutral toward an anchor rod (or ground rod) that is being damaged, and from a ground rod toward the neutral where the ground rod is protected or is accumulating a deposit due to the current.

The significance of readings that are taken will vary with the existing conditions, but by taking measurements at a number of anchors or ground rods and visually checking

anchor rods of known age where the highest currents are measured, a method of checking for incipient failures can be developed. In general, it may be desirable to check anchor rods where the measured currents are highest if these currents are in the order of 10 milliamperes or more and anchor rods have been installed for at least five years.

It should be recognized that the direct current flowing into an anchor will be higher if measurements are made between the anchor and system neutral than it will be between the anchor and a single ground; also, it will vary with soil moisture and temperature and is likely to be larger where the individual ground is a system ground than if it is a higher resistance pole ground.